

9.10 PRELIMINARY MEASUREMENTS OF AURORAL ENERGY DEPOSITION AND MIDDLE ATMOSPHERE ELECTRODYNAMIC RESPONSE DURING MAC/EPSILON

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On the nights of October 21 and 28, 1987 (UT), two Nike Orion payloads (NASA 31.066 AND 31.067) were launched from Andoya, Norway, as part of the MAC/Epsilon campaign, to study auroral energetics and their effect on the middle atmosphere. Each payload carried instrumentation to measure relativistic electrons from 0.1 to 1.0 MeV in 12 differential channels, and Bremsstrahlung X-rays from > 5 to > 80 keV in 5 integral channels. In addition, instrumentation to measure ion densities and electric fields were also included on these and, in the case of 31.066, on other near simultaneous payloads. The first flight, 31.066, was launched under pre-magnetic midnight conditions during relatively stable auroral conditions. Flight 31.067 was launched during post-breakup conditions, at which time pulsations of approximately 100 seconds duration were evident. The measured radiations including their spectral characteristics are compared for these two events, to appraise their effect on the electrodynamic properties of the middle atmosphere as determined by other rocket-borne measurements.

31.066/31.067 MAC/EPSILON

Scientific Team

<u>Instrument</u>	<u>Investigators/affiliation</u>
Solid state detector	R. A. Goldberg, NASA/GSFC
X-Ray detector	J. R. Barcus, Univ. Denver
Geiger tube	R. A. Goldberg, J. R. Barcus
Nosetip probe	J. D. Mitchell, S. Blood, Penn. State Univ.
Conductivity probe	L. C. Hale, C. L. Croskey, Penn. State Univ.
Positive ion probe	E. Thrane, T. Blix, NDRE
3D-Electric field	L. C. Hale, C. L. Croskey
Wind Spectrometer	F. A. Herrero, NASA/GSFC

Figure 1. During MAC/Epsilon two Nike Orion rockets were launched from Andoya, Norway, to study auroral energetic radiation and middle atmosphere response in both a neutral and electrodynamic sense. Each payload carried the listed instrument complement. The figure also lists the scientific team. Upon reaching about 90 km, each payload was despun and pointed along the earth's magnetic field, thereby permitting radiation measurements in a controlled pitch angle environment.

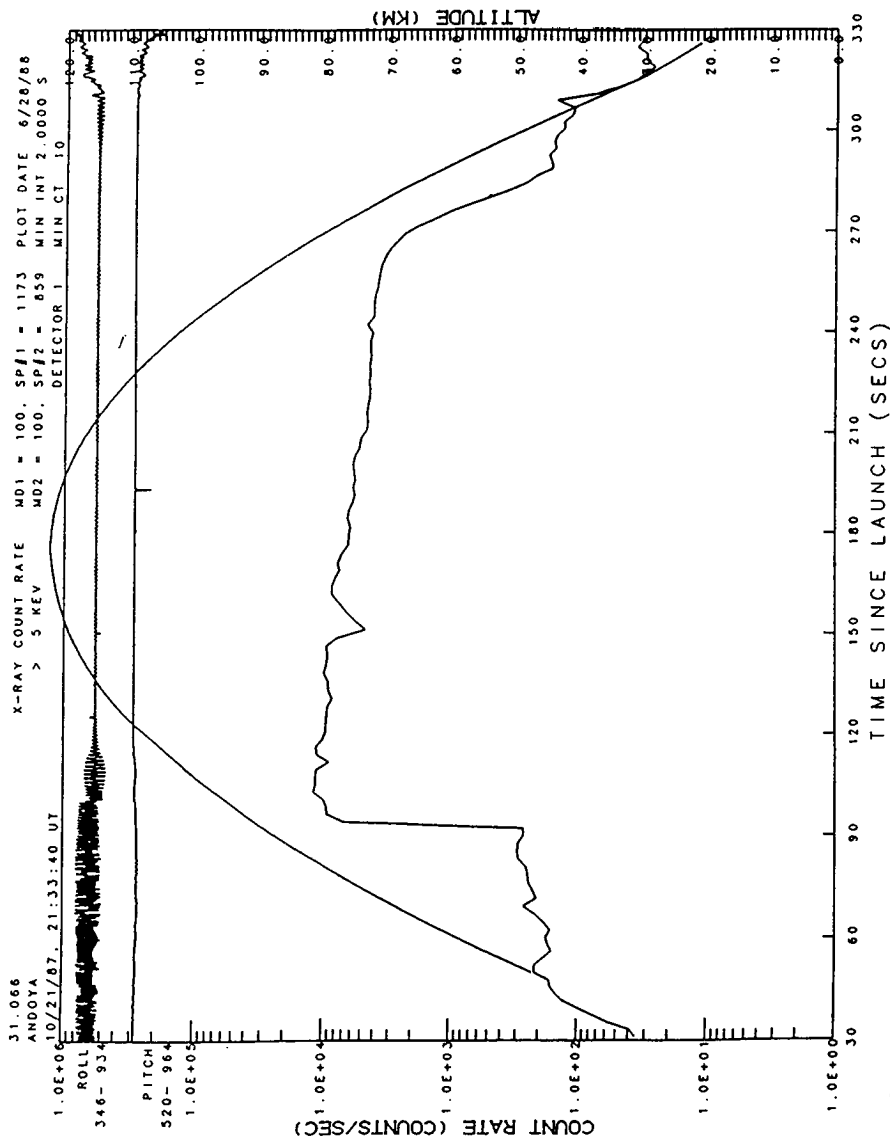


Figure 2. The first payload, 31.066, was launched on the night of October 21, 1987, as part of a near simultaneous 5 rocket series. Launch occurred during the recovery phase of a magnetic substorm with the local sidereal time a little less than 1 dB absorption. The figure displays count rates measured by the forward-looking X-ray scintillator detector in the 75 keV channel along with the trajectory as a function of time. Also shown are the magnetic pitch and roll exhibiting the despin and magnetic field alignment. From detector exposure at nose cone deployment near 90 km, X-ray detector count rates show a linear decline with time. Comparison with the solid-state detector data (12 differential channels above 90 keV) shows similar characteristics, implying that the X-ray detector is primarily responsive to relativistic electrons above 90 km.

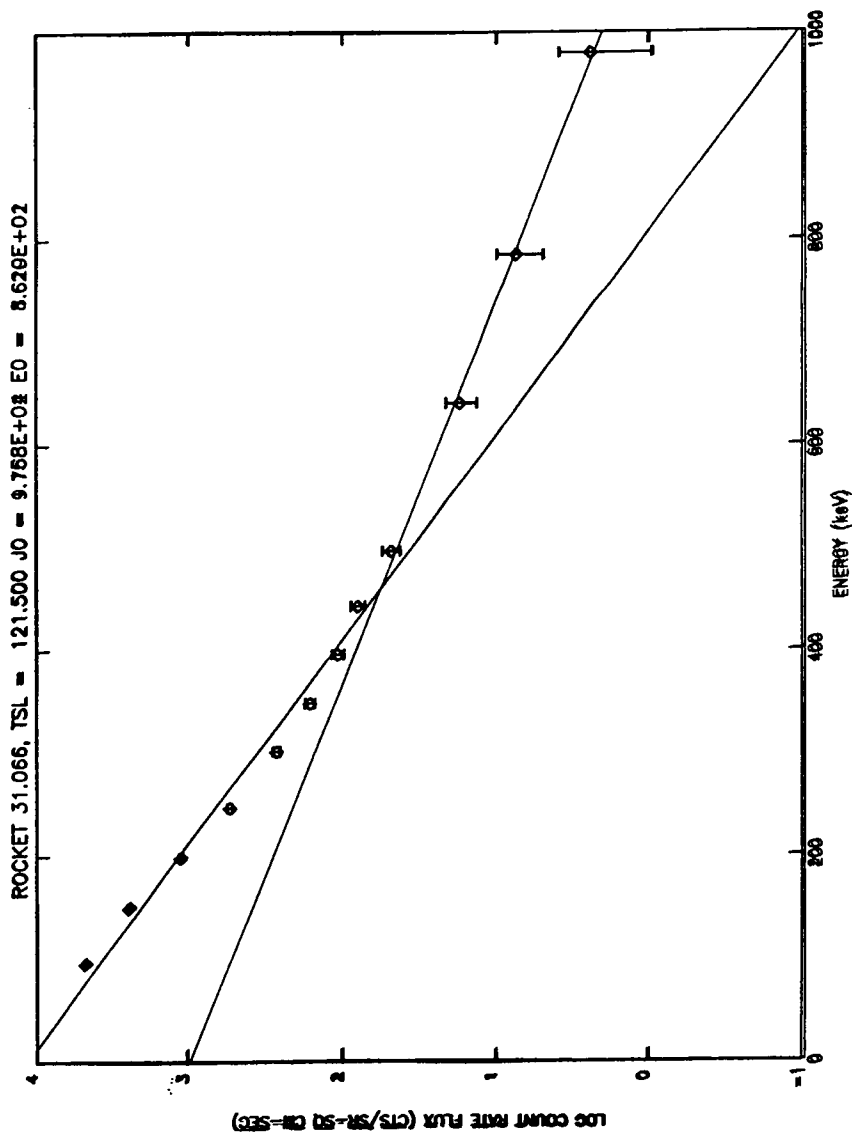


Figure 3. The integral spectrum shown here was obtained from the solid-state detector during the 1 second period about 121.5 s into the flight. It shows a two-component spectrum with a break point near 450 keV, having E_0 folding energies of about 86 and 162 keV below and above 450 keV, respectively. These values for $1 E_0$ were maintained throughout the flight.

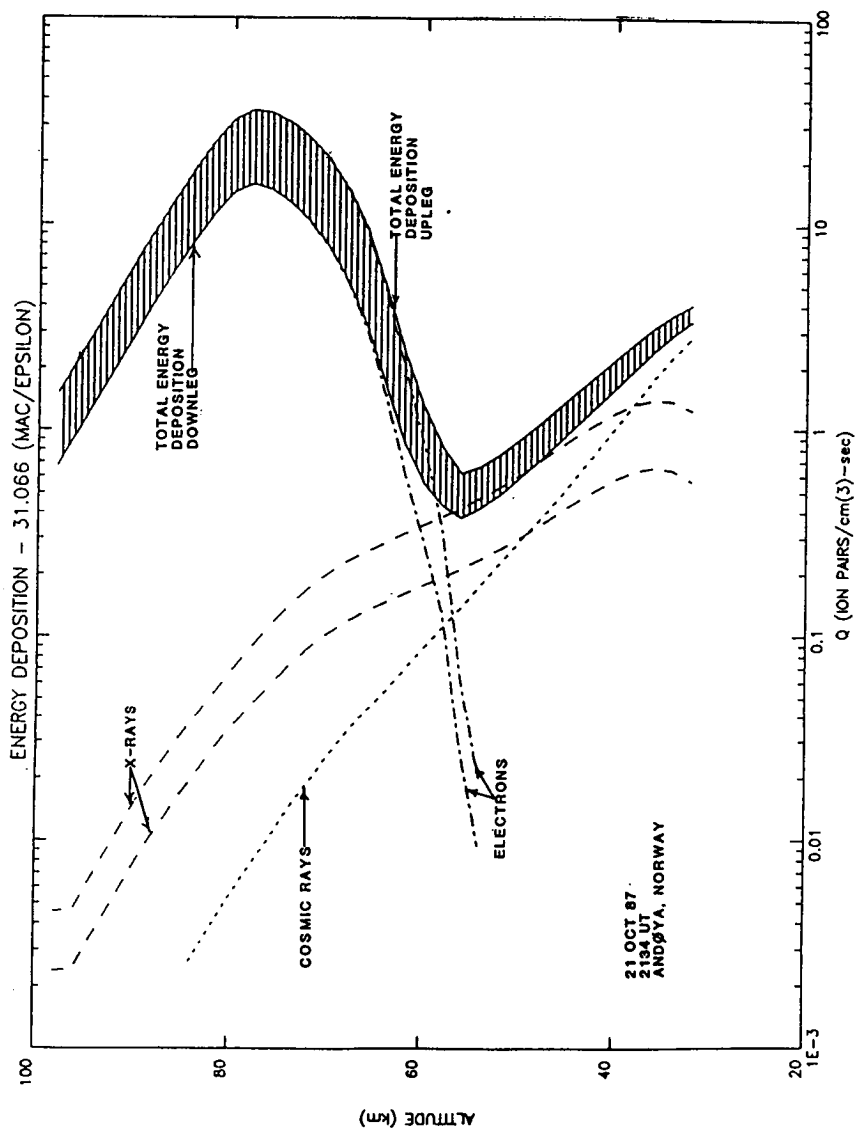


Figure 4. The X-ray and relativistic electron measurements have been used to calculate an energy deposition profile within the atmosphere, given as an ion-pair production rate. The upper and lower bounds of the decaying flux are given by the upper and lower boundaries of the shaded curve. Individual contributions from X-rays, electrons, and cosmic rays (modeled) are provided. The figure shows a peak in energy deposition near 85 km (for electrons > 90 keV), which remains well above the cosmic ray background to altitudes below 60 km. The dominant flux is controlled by electrons throughout this entire height range.

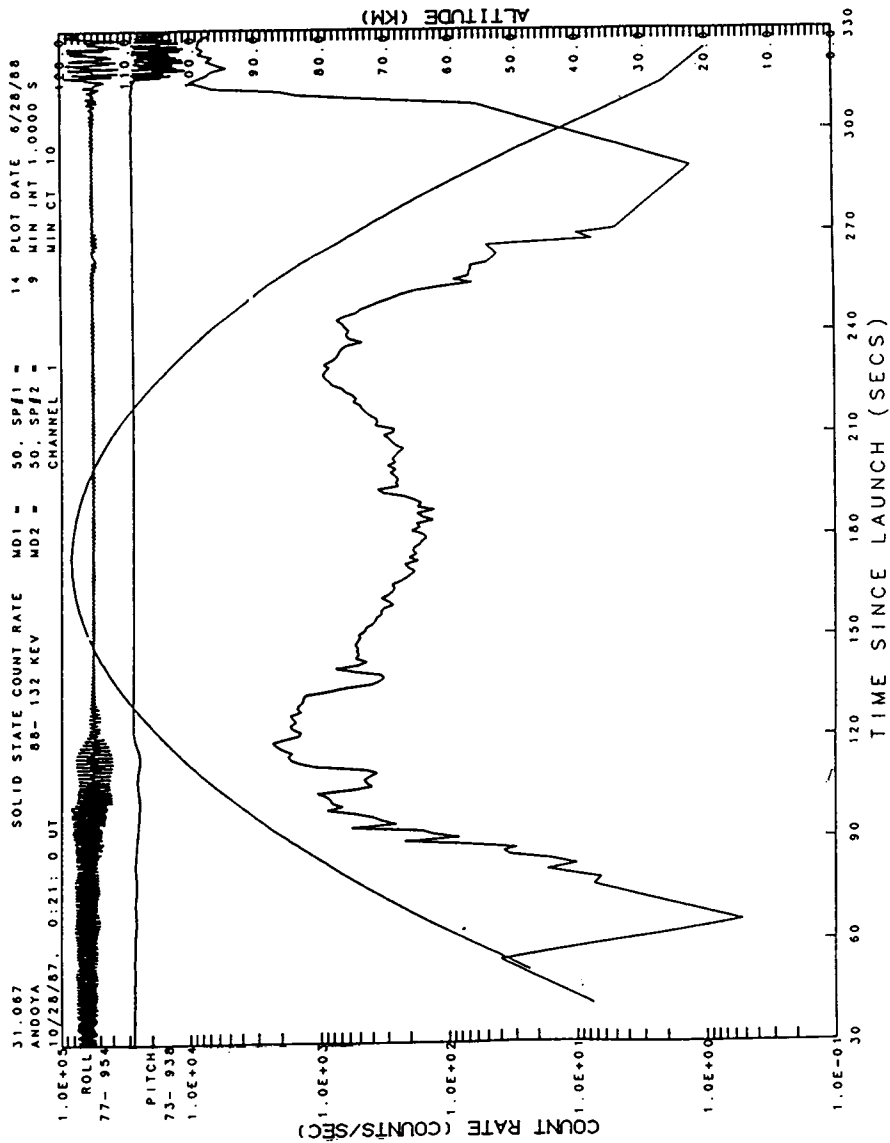


Figure 5. On October 28, 1987, the second Nike Orion (31.067) was launched as a solo rocket during a brief recovery phase of a large magnetic storm (geomagnetic absorption ~ 2 dB). The figure shows count rates from the first channel (88 - 132 keV) of the solid-state detector, which exhibits large pulsations during the early and late portions of the flight.

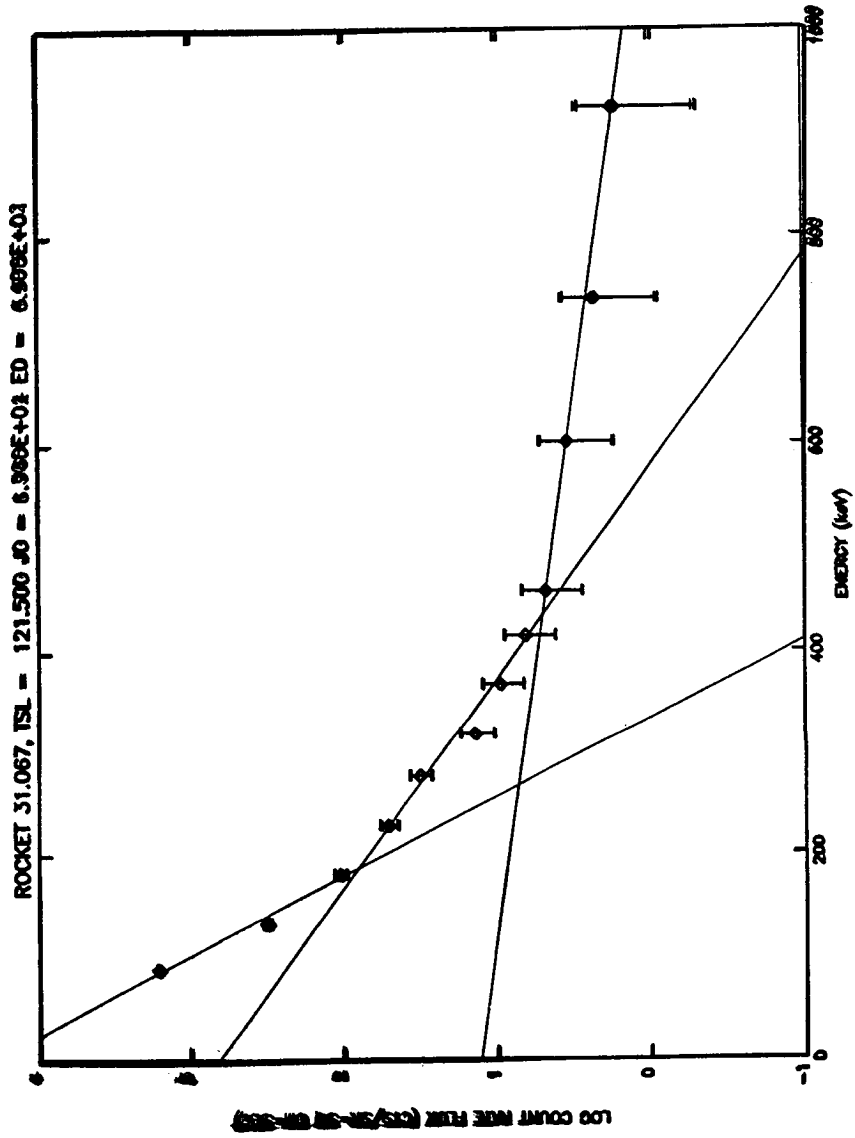


Figure 6. The solid-state detector in this case showed a 3-component spectrum, with the addition of a steep low-energy component. This low energy component (< 100 keV) should have produced large quantities of Bremsstrahlung X-rays, which were seen by the X-ray detectors aboard this payload.

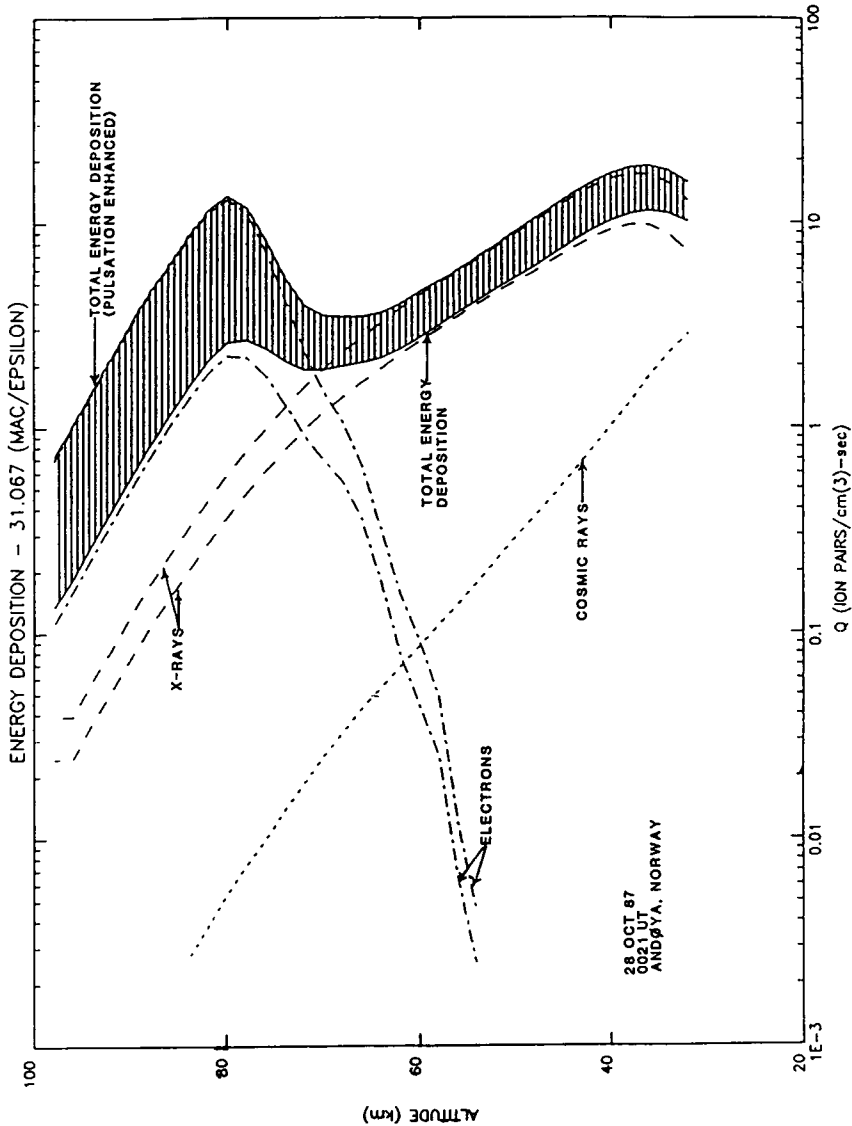


Figure 7. The data obtained from X-ray and particle data on 31.067 were used to determine the energy deposition profiles shown here. The lower and upper bounds on the curves are our current best estimate of the stable and pulsation enhanced contributions. Although the electrons produce an enhancement in the energy deposition peak near 80 km, the dominant source of radiation on this flight was from Bremsstrahlung X-rays, which penetrated significantly below 40 km. These were probably produced by the huge flux of lower energy electrons, not present on the night of the 31.066 flight.

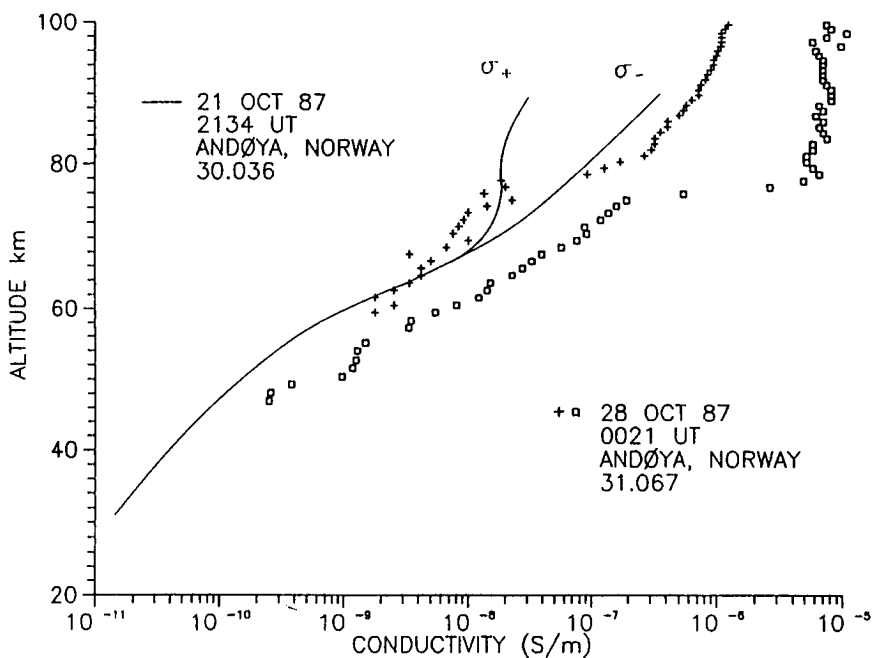


Figure 8. This figure shows conductivity profiles obtained during each rocket flight. On October 21, 1987 (31.066), there is a change in slope near 60 km, reflecting an enhancement in the conductivity profile which demonstrates a departure from cosmic rays as the primary ionizing source. Above 65 km, the positive and negative conductivity curves separate, indicating the presence of free electrons. For the night of October 28, 1987 (31.067), the huge source of Bremsstrahlung X-rays maintains free electrons down to approximately 50 - 55 km, with an enhanced conductivity above the expected cosmic ray level to much lower altitudes. The conductivity profiles obtained on both nights are thereby consistent with the measured energy deposition profiles. The enhanced conductivities above 80 km for October 28 are attributed to the lower energy electrons (< 90 keV) which were not directly measured in spectral form on either flight and thereby not reflected in the energy deposition curves at this time.